Evaluating Debris Removal from Circular Holding Tanks by Lifting the Holding Tank Screen at the Tracy Fish Collection Facility

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Summary

The U.S. Bureau of Reclamation (Reclamation) Tracy Fish Collection Facility (TFCF) was built in 1956 to remove Chinook salmon (*Oncorhynchus tshawytscha*) and striped bass (*Morone saxatilis*) ≥20 mm FL from the Delta-Mendota Canal (DMC). Once fish are removed from the DMC, they are held in concrete holding tanks (6.1 m diameter × 5 m deep), equipped with lift-able cylindrical wire-mesh holding tank screens (2.4 m diameter × 5 m deep), for 8–12 h and then transported by truck for release in the northern Sacramento-San Joaquin Delta (SSJD) beyond the immediate influence of the C.W. "Bill" Jones Pumping Plant (JPP) in a process known as the "haul-out." The number of fish salvaged and hauled-out at the TFCF is estimated by performing a "fish count," in which a sub-sample of the water flowing into the tanks is taken every 2 h. Along with fish, large amounts of Brazilian Elodea (*Egaria densa*) or woody debris (*i.e.,* sticks, twigs, root balls) can accumulate in the holding tanks at the TFCF. This debris can be a major problem because it can impact overall fish survival when the fish count or haul-out buckets clog and can also complicate fish count and haul-out procedures when extra labor is needed to remove the debris from clogged buckets (J. Imai 2009, personal communication). In this study, we will evaluate if quickly lifting the holding tank screen for a fraction of a second ("Lift Method") to allow debris to pass under the screen and away from the fish is an effective debris removal technique during the fish count and haul-out processes. This action may sacrifice a small percentage of the fish in the holding tank but allow the remaining fish to be safely transported to the haul-out truck or be more accurately counted in the fish count station, resulting in overall improved fish survival and more accurate estimates of fish salvage. This allows for the appropriate determination of fish-haul frequency and promotes acceptable fish transport conditions.

This project was started in 2006 and focused on *E. densa*. Our results indicate it takes 16.25–21.25 kg of *E. densa* to clog the fish count bucket and 90–105 kg to clog the haul-out bucket. The fish count station is full when 7.65 kg of *E. densa* is present.

It takes 4.44 minutes (min) of time, on average, to collect and dump the extra sample that is generated when using the "Lift Method" during the fish count process to remove excessive debris. This amount of extra time could prove to be less than the extra time required to process a fish count sample with the debris remaining and ultimately benefit fish survival at the TFCF. The amount of extra time it takes to perform the "Lift Method" during the haul-out process will also be determined and may be greater than that found for the fish count process due to the longer distance that the haul-out bucket is hoisted and the heavier weight of the haul-out bucket. In general, increased debris loads in the fish count station results in increased processing time, more processing errors and more missed fish.

Repetitions completed with both the fish count and haul-out buckets in which debris was injected and the "Lift Method" was not performed suggest the percentage of *E. densa* recovered decreased as the amount injected increased and the percentage of *E densa* lost increased with increasing debris load. Depending on the amount of debris entering the holding tank, 4.8–59.6% of the debris is lost during routine facility fish counts and haul-outs. White catfish are the species most likely lost during routine fish count and haul-out processes and threadfin shad are the least likely to be lost among the debris during these activities.

Repetitions completed with the fish count bucket in which debris was injected and the "Lift Method" was performed suggest that, in general, the sample collected after lifting the holding tank screen ("pre sample") contained more *E. densa* than the sample left in the holding tank ("post sample"). The "pre sample" contained 60% of the injected *E. densa*, on average, while the "post sample" contained an average of 16.3% of injected *E. densa*. The "pre sample" contained, on average, 38% of the fish from the holding tank and left, on average, 60% of the fish to be collected in the "post sample."

Repetitions completed with the haul-out bucket in which debris was injected and the "Lift Method" was performed indicates that, on average, 50.4% of injected debris is removed by the "Lift Method" and contained in the "pre sample." On average, only about 21.75% of the injected debris was left in the holding tank to be collected in the "post sample." The "Lift Method" is especially beneficial to threadfin shad while using the haul-out bucket. This is apparent because 65–100% (87.5% on average) of the injected threadfin shad remained in the holding tank after the "Lift Method" was performed and were collected in the "post sample." This high retention in the "post sample" was different than that found for white catfish and Sacramento splittail which demonstrated a 15–65% (37.5% on average) and 0–35% (20% on average) retention in the "post sample," respectively, when using the haul-out bucket.

During real-time facility fish counts, the "Lift Method" removed, on average, 40% of the *E. densa* and 16.5% of the fish in the "pre sample." Therefore, on average, 83% of the fish and 60% of the *E. densa* collected during the facility fish counts were left in the holding tank after performing the "Lift Method" and were collected in the "post sample."

This project was started in 2006. Work on this project was delayed in 2007 due to construction activity. Little work was completed during the 2008, 2009, and 2010

seasons due to larval smelt sampling activity at the TFCF. This project will continue through December 2011. Upon completion, this debris removal process could be utilized at the TFCF as an alternative to expensive screening techniques that require extensive testing and engineering design.

Problem Statement

At the TFCF, fish are collected and held in 6.1-m-diameter holding tanks for 8–12 h before they are released in a process known as the "haul-out." During the 8–12 h collection and holding time, large amounts of Brazilian elodea can accumulate in the holding tanks and can impact fish survival when the fish count or haul-out buckets clog or complicate the fish count and haul-out procedures when extra labor is needed to remove the debris from the clogged buckets (Imai 2009, personal communication). Large amounts of debris in the fish count station can also cover or hide fish, which, when uncounted, could potentially result in reduced accuracy of fish salvage estimates used to determine when haul-outs are necessary. The primary objective of this study is to determine if lifting the holding tank screen, for less than 1 s, prior to collecting fish in the fish count and haul-out buckets is a cost efficient, effective and time conserving debris removal technique for periods when debris loads are excessive in the TFCF holding tanks.

Goals and Hypotheses

Goals:

1. Determine the range of debris load in the holding tank in which the "Lift Method" prevents each bucket from clogging.

2. Determine the range of debris load in the holding tanks in which the percent fish loss for the "Lift Method" is below that for the routine fish count process when fish are lost in debris and left uncounted or when the fish count bucket clogs (assumed 100% mortality).

3. Determine the range of debris load in the holding tanks in which the percent fish loss for the "Lift Method" is below that for the routine haul-out process assuming that there is 100% fish mortality (loss) when the haul-out bucket clogs.

4. Determine the range of debris load in the holding tanks in which the time it takes to complete the fish count and haul-out processes, using the "Lift Method," is less than that required to complete the fish count or haul-out processes using the normal method.

Hypotheses:

1. The processing time for handling fish, the number of errors, and the number of missed fish will be the same for normal operation and when performing the "Lift Method" during the fish count process.

2. The amount of debris remaining in the holding tanks during the fish count and haul-out processes will be the same for normal operation and the "Lift Method."

3. The percent of fish retained in the fish count and haul-out buckets will be the same for normal operations and the "Lift Method."

4. The survival of fish in the fish count and haul-out buckets will be the same for normal operation and the "Lift Method."

5. The amount of time to complete the entire fish count and haul-out processes will be equal for normal operation and when performing the "Lift Method."

Materials and Methods

Haul-Out Procedure "Lift Method" Extra Time

The time it takes to collect and dump the extra sample that is generated while performing the "Lift Method" will be determined using an empty (no water or fish) haul-out bucket. The extra time it takes two operators (three trials each/holding tank) to hoist the empty haul-out bucket from both holding tank 3 and 4 pits to the fish-haul truck (seated on the fish-haul truck) and back to the holding tank pit will be determined.

Timed Fish Counts

The accuracy and length of time it takes for a TFCF operators to complete a fish count (count fish and separate them from *E. densa*) will be determined for three different debris loads. In order to replicate typical fish densities in the counts, 15 Sacramento splittail (*pogonichthys macrolepidotus*), 15 Sacramento blackfish (*Orthodon microlepidotus*), 15 threadfin shad (*Dorosoma petenense*), 3 Chinook salmon and 2 striped bass will be added to each fish count trial along with 1 of 3 *E. densa* loads. The three debris loads that will be used are 0, 2.55, and 7.65 kg. The 0-kg and 2.55-kg amounts of *E. densa* will be tested in order to simulate times when little or no debris is collected in the holding tanks during the fish count. The 7.65-kg amount was chosen to be tested because this amount of *E. densa* was determined to clog the fish count station and was the maximum amount of debris that could be used.

The *E. densa* (if any) and fish will be put into the fish count station and mixed thoroughly. Once the operator starts the fish count, the timer will be started. The time will be stopped when the test subject believes that they have retrieved all of the fish from the fish count station. The amount of time taken to complete the fish count, the weight and percentage of the debris recovered, and the number of errors and missed fish will be determined for each trial and debris load.

Injection Trials - "Lift Method" Not Performed

Injection trials will be completed in which the "Lift Method" will not be performed (normal fish count). These trials will be performed during times when the natural debris entering the holding tank through the collect pipe is minimal (<1 kg). In these control trials, five different amounts of *E. densa* (4.2, 10, 18.46, 40 and 60 kg) will be injected into holding tank 2, along with 60 juvenile fish. The tank will then be swirled

(collect and drain initiated) for 10 min. The fish count bucket will be used for the trials where 4.2, 10 and 18.46 kg of debris will be tested. The haul-out bucket will be used for the 40- and 60-kg injection trials. The 60 juvenile fish (<200 mm FL) will consist of 20 threadfin shad, 20 Sacramento splittail and 20 white catfish (*Ameirus catus*). After the 10-min swirl time, holding tank 2 will be drained down to an approximate depth of 0.61 m, and the fish count bucket will be inserted into the drain. The holding tank screen will be lifted and the debris and fish will be collected. The bucket will then be lifted out of the drain and all collected debris and fish will be dumped into the fish count station for processing (weighing, measuring, and counting). This information will allow us to determine a baseline loss of debris and fish during routine facility fish counts that contain debris loads of 4.2, 10, 18.46, 40 and 60 kg. One trial was performed for each of the debris loads tested. It is necessary to perform at least two more trials for each amount of debris tested in our injection trials in which the "Lift Method" will not be performed.

Controlled Debris Injection Trials – "Lift Method" Performed

1. Fish Count Bucket

In order to determine how much debris is removed from the fish count sample with the "Lift Method" controlled debris injection test will be completed. These tests will be performed during times when the amount of *E. densa* introduced into the holding tank through the collect pipe is minimal (<1 kg). Four amounts of *E. densa* (10, 16, 21 and 26 kg) will be tested based on the bucket clogging density tests previously described. Each treatment will be injected into a clean holding tank along with 60 fish, a typical number of fish seen during a fish count. The 60 juvenile fish (<200 mm FL) will consist of 20 threadfin shad, 20 Sacramento splittail, and 20 white catfish. The upper caudal fin of all injected fish will be fin-clipped. The holding tank will be swirled for 10 min (collect and drain initiated). After this, the holding tank will be drained to an approximate depth of 0.61 m and the fish count bucket will be inserted into the drain. The holding tank screen will then be quickly lifted and lowered ("Lift Method"). Once the debris had fallen into the fish count bucket, it will be lifted out of the drain and contents will be dumped into the fish count station for processing (weighing and counting). This sample will be called the "pre sample." Ideally, this sample should contain as much of the *E. densa* as possible while leaving the fish to be collected in the "post sample." The fish count bucket will then be lowered into the holding tank drain and the remaining fish and debris in the holding tank will be washed into the bucket. The second bucket ("post sample") will be lifted and processed in the same manner as the first bucket. The quantity of fish and debris in the two samples will allow us to determine the percentage of debris removed and the percentage of fish lost by lifting the holding tank screen. One repetition was completed for the 10-, 16- and 21-kg *E. densa* loads while three repetitions were completed for the 26-kg *E. densa* load. Due to this, it is necessary to complete two more controlled debris injection trial repetitions for the 10-, 16- and 21- kg *E. densa* loads using the fish count bucket.

2. Haul-Out Bucket

To determine how much *E. densa* is removed from the haul-out holding tank sample with the "Lift Method," a controlled *E. densa* injection test will be completed. These tests will be performed during times when the amount of *E. densa* introduced into

the holding tank through the collect pipe is minimal (<1 kg). Four quantities of *E. densa* (28.91, 40, 53.8 and 90 kg) will be separately injected into a holding tank, along with 60 fish. The 60 juvenile fish (<200 mm FL) will consist of 20 threadfin shad, 20 Sacramento splittail, and 20 white catfish. The upper caudal fin of all injected fish will be fin-clipped. Once the *E. densa* and fish have been injected into a full holding tank, the tank will be swirled for 10 min and then drained down to an approximate depth of 0.61 m. The haul-out bucket will then be inserted into the drain. The holding tank screen will be quickly lifted and lowered twice. The bucket will then be lifted out of the drain and the contents dumped into a 355.6-cm-long × 73.66-cm-wide × 76.2-cm-deep trough. The *E. densa* will then be separated and weighed. The bucket will again be lowered into the holding tank drain and the remaining *E. densa* and fish will be washed into the bucket. The second bucket will be lifted and processed in the same manner as the first bucket. This will allow us to determine the percentage of debris removed from the haul-out sample by lifting the holding tank screen for each debris weight injected. One repetition was completed for the 28.91-, 40- and 53.8-kg *E. densa* loads. Two repetitions have been completed for the 90-kg *E. densa* load. Therefore, two more repetitions are necessary for the 28.91-, 40-, and 53.8-kg debris loads and one more repetition is necessary for the 90-kg debris load.

Real-Time Facility Evaluation

1. Facility Fish Counts

In order to validate the "Lift Method" with the fish count process, it will be necessary to test the method during the actual facility fish counts. The "Lift Method" will be performed during routine fish counts in order to obtain pre and post samples. In the pre and post samples, the fish will be separated from the debris and a total weight of debris will be obtained. Twenty four measurements of each species of fish in each sample will also be made and any remaining fish will be identified and counted. Three repetitions were completed and at least five more facility fish count samples are necessary.

2. Facility Haul-Outs

In order to evaluate the effect of lifting the holding tank screen during the haul-out process it is necessary to attend the regularly scheduled haul-outs (generally done at 0700 and 1530) during a time when there is a significant debris load. The pre and post samples will be processed in the same manner as was done during the fish count evaluation except that the fish will be processed in a large above-ground trough. If the debris and fish quantity in the pre sample is so large that the number of fish cannot be hand counted then their numbers will be estimated based on the fraction of the total debris weight that was fish. If the post sample contains many thousands of fish and cannot be hand counted, the quantity and type of fish in the holding tank will be estimated from the "Fish Daily Tally Sheet" which provides an estimate of the total number of fish present in the haul-out tank. This estimate is based on the fish count samples taken every 2 h. The estimated number of fish and total amount of debris in the tank along with the known number of fish and amount of debris in the pre and post samples will allow us to determine what percentage of the fish and debris in the tank was

lost in the pre sample. At least eight real-time facility haul-out evaluations will be completed by the end of this study.

Data Analyses

1. Clogging Evaluation

The approximated amount of debris that it takes to clog each type of equipment (fish-count bucket, fish-count station, haul-out bucket, and fish-haul truck) will be used as a guideline for proper facility operation.

2. Timed Fish Counts

Regression analysis will be used to determine if there is a predictable relationship between holding tank debris load and sample processing time. An analysis of variance will be used to determine if there is a predictable relationship between holding tank debris load and the number of errors or missed fish.

3. Controlled Debris Injection Trials

We will use regression analysis to determine if there is a relationship between the amount of debris in the post sample and the amount of debris present in the holding tank sample. Regression analysis will also be used to determine if there is a relationship between the percentage of fish lost and the amount of debris in the post bucket after debris is removed in the pre bucket using the "Lift Method." Processing time, for each debris load, with and without performing the "Lift Method," will also be plotted and predicted with regression.

4. Real-Time Facility Operations

Debris removal by performing the "Lift Method" will be implemented for both regularly scheduled fish counts and haul-outs. A regression will be used to compare the amount of debris remaining in the fish count post bucket with the amount determined to obstruct the fish count bucket or the fish count station. A regression will also be used to evaluate the amount of debris remaining in the haul-out bucket relative to the amount determined to obstruct the haul-out bucket or fish haul truck. We will use regression to compare the quantity of fish lost using the lift method compared to normal operations.

Coordination and Collaboration

All experiments will be coordinated with the TFCF Fish Diversion Workers and the TFCF Biology staff. We are planning on continuing debris removal research with *E. densa* during June, July, August, and September of 2010 and 2011. During this time we will complete the controlled injection trials and the real-time facility trials. Timed fish count trials will be done whenever possible, depending on the availability of operators and their workload.

Endangered Species Concerns

No ESA listed species will be targeted during the period of this study. It is possible that there will be incidental "take" of ESA listed salmon, steelhead and/or delta smelt. If collected, ESA listed salmon, steelhead, and delta smelt will be measured and released alive back into the normal salvage operations.

Dissemination of Results (Deliverables and Outcomes)

A Tracy Series Report Volume will be prepared and published upon completion of this study. Updates and presentations of progress will be provided internally and upon request by TTAT and other interagency technical forums. We will have the data analysis for the *E. densa* removal trials completed by December 2011 and will have a draft report finished by April 2012 for internal review. A final draft report for TTAT review will be completed by the end of June 2012.

Literature Cited

Arthur, J.F., M.D. Ball, and S.Y. Baughman. 1996. *Summary of federal and state water project environmental impacts in the San Francisco Bay-Delta Estuary, California*. Pages 445-495 *in* J.T. Hollibaugh, editor. San Francisco Bay: The Ecosystem, Further Investigations into the Natural History of San Francisco Bay and Delta with Reference to the Influence of Man. Pacific Division of the American Association for the Advancement of Science, California Academy of Sciences, San Francisco, California.

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